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PTO/SB/05 (4/98)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	103.1037.01
First Inventor or Application Identifier	Steven Kleiman
Title	Communication Of Control Information And Data In Client/Server Systems
Express Mail Label No.	EL 524 781 265 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, DC 20231

1. □ * Fee Transmittal Form *(e.g., PTO/SB/17)*
(Submit an original and a duplicate for fee processing)

2. ☒ Specification [*Total Pages* 19]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings *(if filed)*
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 2]

4. Oath or Declaration [*Total Pages*]
a. □ Newly executed (original or copy)
b. □ Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
i. □ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b)

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5. □ Microfiche Computer Program *(Appendix)*

6. Nucleotide and/or Amino Acid Sequence Submission
(*if applicable, all necessary)*
a. □ Computer Readable Copy
b. □ Paper Copy (identical to computer copy)
c. □ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. □ Assignment Papers (cover sheet & document(s))
8. □ 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* □ Power of Attorney
9. □ English Translation Document *(if applicable)*
10. □ Information Disclosure Statement (IDS)/PTO-1449 □ Copies of IDS Citations
11. □ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. □ * Small Entity Statement(s) *(PTO/SB/09-12)* □ Statement filed in prior application, Status still proper and desired
14. □ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
15. ☒ Other: Certificate of Mailing

16. **If a CONTINUING APPLICATION,** *check appropriate box, and supply the requisite information below and in a preliminary amendment.*
□ Continuation □ Divisional □ Continuation-in-part (CIP) of prior application No. ________/__________________
Prior application information: Examiner ______________________ *Group / Art Unit:* ________________

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

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Printed Name

Roberta D. Roberts
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This application includes:

- Utility Transmittal Form SB/05
- Specification 12 page(s)
- Claims 6 page(s)
- Abstract 1 page(s)
- Drawings 2 page(s)
- Certificate of Mailing
- Return Postcard

This application is submitted in the name of the following inventor(s):

Inventor Name	Citizenship	Residence City and State
Kleiman, Steven R.	United States	Los Altos, California

The assignee is Network Appliance, Inc., a corporation having an office at 495 Java Drive, Sunnyvale, California, 94089.

TITLE OF THE INVENTION

Communication of Control Information and Data in Client/Server Systems

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to computer communication, such as in client/server systems.

Related Art

One known model for assigning or performing tasks in a computer system is a client/server model. In a client/server model, clients make requests for service (by sending messages) to a server; the server responds to those requests for service by providing services to requesting clients (and possibly sending messages back to requesting clients). For example, the server might include a file server responsive to file system requests, a web server responsive to network object requests, a database server responsive to database requests, or some other type of server. Client/server models are used both internally within a single device (the client and server are different software modules), as well as between different devices (the client and server are coupled by a communication link).

When the client and server are different devices, they communicate using a communication link. In byte serial systems, messages between devices are sent and received using a communication protocol. Each message has prepended header information indicating its intended recipient, payload information, and appended checksum information. The sender thus wraps the message inside a serial byte stream, which the receiver unwraps to determine what the message is. Often, the communication protocol will be multi-layered — a lower-level protocol carries multiple types of messages, while different higher-level protocols carry messages suited to particular purposes. Thus, higher-level protocol messages package communication between the client and server, while lower-level protocol messages break up the higher-level protocol messages and package portions of it for sending between devices.

While byte serial models are designed for a very open and diverse environment, they are not well suited to rapid communication of relatively large blocks of data. First, relatively large blocks of data must generally be broken up by the sender into smaller messages, so as to accommodate the message sizes of intermediate communication links. Similarly, the smaller messages must be reassembled at the receiver into the relatively larger blocks of data; this is called fragmentation and reassembly. Second, payload information is not reliably located at any aligned location when received; this causes the receiver to move the payload information into a buffer where the block of data is aligned at a known position. Third, checksum information is computed by the sender and checked by the receiver for each message; this produces substantial computing overhead for each message and for each block of data. Fourth, the receiver must generally be prepared to receive messages of up to the largest possible size; this causes the receiver to allocate maximum size buffers, which are often larger than necessary.

Another known method for communicating data includes DMA (direct memory access) transfer of data between devices. One such method of DMA transfer is known as NUMA (non-uniform memory access); examples of NUMA architectures include Infiniband, ServerNet and interconnection networks compliant with the VI

(Virtual Interface) architecture standard such as cLan, Servernet II, and FC-VI. Using a DMA transfer, the initiating device transfers data directly to or from a memory for the target device. The specific memory locations on the target device are specified by the initiator using addresses associated with addresses on the target device. While NUMA architectures are well suited to rapid communication of relatively large blocks of data, they are not generally designed to support high latency wide area networks or to support networks in which export of memory is problematic for security reasons. NUMA architectures are best suited to communication between devices that are closely coupled, both using hardware (relatively short haul communication links) and software (relatively closely cooperating system elements).

One system has used NUMA architecture for communication in a client/server architecture. The Microsoft "Winsock Direct Path" sends messages between client and server using both a TCP/IP communication link and a NUMA communication link. The Winsock Direct Path architecture, after wrapping the message for communication between the sender and the receiver, determines if there is a NUMA communication link available; if so, the Winsock Direct Path architecture uses that NUMA communication link to send the message; if not, the Winsock Direct Path architecture uses the TCP/IP communication link. While the system has some of the advantages of communication using a NUMA architecture, it still has the drawbacks noted earlier for byte serial models of communication in a client/server architecture.

Accordingly, it would be advantageous to provide a technique involving computer communication systems, such as those using a client/server model, that is not subject to drawbacks of the known art.

SUMMARY OF THE INVENTION

The invention provides a method and system in which a client/server system uses a NUMA communication link, possibly in combination with a byte serial communication link, to transfer relatively large blocks of data between client and server. The method and system provides for transferring data between the client and server, in which timing for the actual data transfer is decoupled from a request (from the client) or a response (from the server). The method and system also provides for transferring data from either party to the other at mutually agreed locations, such as locations responsive to control information present in either the request or the response. Accordingly, either party can transfer data to the other at a location convenient to both the sender and the recipient, and either party can process data in any order it prefers, without regard for the order in which data is stored at the other party.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of a client/server system using a NUMA communication link.

Figure 2 shows a process flow diagram of a method of using a system as in figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

System Elements

Figure 1 shows a block diagram of a client/server system using a NUMA communication link.

A system 100 includes a server 110, a communication link 120, and one or more clients 130.

The server 110 includes a processor, server program and data memory 111, and server mass storage 112. The server memory 111 includes server software 113, including instructions for receiving requests from clients 130 and providing responses to clients 130, and server data buffers 114, including locations for receiving information from clients 130 and for recording information for access by clients 130.

The server data buffers 114 are matched to the size of data blocks to be transferred into or out of those server data buffers 114. Accordingly, a first set of server data buffers 114 are relatively larger (such as about 4 Kbytes), so as to accommodate relatively larger data blocks such as disk blocks. A second set of server data buffers 114 are relatively smaller (such as about 256 bytes), so as to accommodate relatively smaller data blocks such as control information. As described in detail below, control information can include memory addresses (either at the server 110 or at the client 130), client/server requests or responses, status information, checksums, or other information for communication between client 130 and server 110 that is relatively smaller than a disk block.

Although this application describes the preferred embodiment as having one server 110, this description is for simplicity only. An embodiment of the system may include more than one server 110, which may each communicate with more than one client 130. The set of servers 110 serving a first client 130 can overlap with the set of servers serving a second client 130; similarly, the set of clients 130 being served by the first server 110 can overlap with the set of clients being served by a second server 110. Moreover, servers 110 can communicate with each other, and clients 130 can communicate with each other, including using techniques described herein with regard to client/server communication.

The communication link 120 includes one or more NUMA communication links 121. In an alternative embodiment, the communication link 120 might also include one or more byte serial communication links 122; however, these adjunct byte serial communication links 122 are not required.

The NUMA communication links 121 allow clients 130 and servers 110 to read or write directly into each other's memory 131 or memory 111, using DMA memory read and write operations. Thus, the server 110 can read or write directly into or out of client memory 131, or clients 130 can read or write directly into or out of server memory 111. There is no particular requirement regarding which locations in the client memory 131 or server memory the client 130 or server 110 can read or write directly into or out of. Target addresses may have to be explicitly exported before they are remotely accessible; however in a preferred embodiment, server 110 does not export memory.

In an alternative embodiment, the byte serial communication links 122 allow clients 130 and servers 110 to send and receive messages 140 to each other. As noted earlier, these adjunct byte serial communications links 122 are not required.

Similar to the server 110, each client 130 includes a processor, client program and data memory 131, and client mass storage 132. The client memory 131 includes client software 133, including instructions for presenting requests to the server 110 and receiving responses from server 110, and client data buffers 134, including locations for receiving information from server 110 and for recording information for access by the server 110.

Similar to the server 110, the client data buffers 134 are matched to the size of data blocks to be transferred into or out of those client data buffers 134. Accordingly, a first set of client data buffers 134 are relatively larger (such as about 4 Kbytes), so as to accommodate relatively larger data blocks such as disk blocks. A second set of client data buffers 134 are relatively smaller (such as about 256 bytes), so as to accommodate relatively smaller data blocks such as control information. These sets of client data buffers 134 need not be the same size as those of the server 110. The sizes indicated are purely illustrative and in no way limiting.

Requests from the client 110 includes addresses within client buffer 134 where results of a read request or a write request should be directed from the server buffer 114.

Method of Use

A method 200 is performed by the system 100. Although the method 200 is described serially, the steps of the method 200 can be performed by separate elements in conjunction or in parallel, whether asynchronously, in a pipelined manner, or otherwise. Lastly, there is no particular requirement that the method 200 be performed in the same order in which this description lists the steps, except where so indicated.

At a flow point 200, the system 100 ready to begin performing a method 200. The server 110 and the client 130 are ready to send and receive messages.

Request from the Client

At a step 205, the client 130 exports or passes an address located within the client data buffer 134 to the NUMA communication link 121. This address allows computing resources to be used most efficiently because the server 110 can direct it's response to the request in such a way as to make optimal use of the space available in the client data buffer 134. The address of the client data buffer 134 is responsive to the relative size of the data block that will be transferred.

If the request is a read request, a client 130 might pass an address of the client data buffer 134 that should receive the results of a read. If the request is a write request, the client 130 might pass the specific address of the client data buffer 134 that should contain data to be written.

In a step 210, the address is transferred from the NUMA communication link 121 to the server 110.

Response of the Server

At a step 215, the server 110 receives the address of the client data buffer 134 and begins processing it.

At a step 220, the server 110 transfers data from one of the server data buffers 114 to a NUMA communication link 121. It should be noted that the actual data transfer is decoupled from the request of the client 130.

At a step 225, the data is transferred using the NUMA communication link 121 to the specified address in one of the client data buffers 134. If the client request was a read request, the data is transferred from the NUMA communication to the specified address of the client data buffer 134. If the client request was a write request, the server 110 reads the data located at the specified address at a client data buffer 134. In a preferred embodiment, the client data buffers 134 are of different sizes and alignments than the server data buffers 114.

The data transfer can be asynchronious; processing of data can occur in any order that is particularly convenient to the server 110 and client 130 as long as the transfer of the data is responsive to the request.

Alternative Embodiments

Although preferred embodiments are disclosed herein, many variations are possible which remain within the concept, scope, and spirit of the invention, and these variations would become clear to those skilled in the art after perusal of this application.

Generality of the Invention

The invention has general applicability to various fields of use, not necessarily related to e-commerce as described above. For example, these fields of use can include one or more of, or some combination of, the following:

- sending requests from a client device to a database server and transferring data from the database server to a client device in response to the request

- sending requests from a client device to a mail server and transferring data from a mail server to a client device in response to the request

- sending requests from a client device to a cache or proxy server and transferring data from a cache server to a client device in response to the request

- sending requests from a client device to a web server (HTTP) and transferring data from a web server (HTTP) to the client device in response to the request

- sending requests from a client device to an FFT server and transferring bulk data from the FFT server to the client device in response to the request.

CLAIMS

1. A method, including steps of

sending data between a client and a server at an address agreed by said client and said server;

wherein said steps of sending data are responsive to a request or a response between said client and said server; and

wherein said steps of sending data are asynchronous with regard to said request or said response.

2. A method as in claim 1, wherein

said request or said response includes at least some control information; and

said steps of sending data are responsive to said control information.

3. A method as in claim 1, wherein

said request or said response includes at least one memory address;

said steps of sending data are responsive to said memory address, wherein said data is read from or written to a memory in response to said memory address.

4. A system including

a client and server;

a NUMA communication link coupled to said client and server;

a request from said client to server or a response from said server to client; and

a data transfer between said client and server;

wherein said data transfer has a time that is decoupled from a time of said request or response; and

wherein said data transfer has a location that is mutually agreed between said client and server.

5. A system, as in claim 4, also including a byte serial communication link.

6. A system as in claim 4, wherein

either said client or server performs processing of information in said data transfer;

said processing is performed in an order convenient to both said client and server; and

said order is decoupled from an order of said data transfer.

7. A system as in claim 4, wherein said data transfer is responsive to control information in said request or response.

8. A system as in claim 4, wherein said data transfer is responsive to said request or response.

9. A system as in claim 4, wherein said data transfer uses said NUMA communication link.

10. A system as in claim 4, wherein said mutually agreed location is responsive to control information in said request or response.

11. A system as in claim 4, wherein said request or response uses said byte serial communication link.

12. A system including

a server, said server having a memory including a client communication region and a data transfer region;

a remote DMA communication link coupled to said data transfer region;

said client communication region including information regarding a data transfer into or out of said data transfer region;

said data transfer being decoupled in time from said client request region.

13. A system as in claim 12, including a byte serial communication link coupled to said client communication region.

14. A system as in claim 12, including a processing element in said server coupled to said data transfer region, said processing element responsive to a request from a client or a response to a client.

15. A system as in claim 12, including a processing element in said server coupled to said data transfer region, said processing element responsive to control information in said client communication region.

16. A system as in claim 12, including a processing element in said server coupled to said data transfer region, said processing element using information in said data transfer region independently of said remote DMA communication link.

17. A system as in claim 12, including a request from a client or a response to said client having information regarding a location within data transfer region.

18. A system as in claim 12, wherein said client communication region stores a request from a client or a response to said client.

19. A system as in claim 12, wherein said data transfer region stores a data transfer to or from a client.

20. A system as in claim 12, wherein said remote DMA communication link includes a NUMA communication link.

21 A method including

communicating file system requests and responses between a client and a file server;

sending data between said client and said file server using a memory access operation at an address agreed by said client and said file server, wherein said address is responsive to information in said requests or said responses.

22. A method as in claim 21, wherein said memory access operation includes a DMA operation.

23. A method as in claim 21, wherein said memory access operation includes a remote DMA operation.

24. A method as in claim 21, wherein said client includes a database server.

25. A method including

communicating database requests and responses between a client and a database server;

sending data between said client and said database server using a memory access operation at an address agreed by said client and said database server, wherein said address is responsive to information in said requests or said responses.

26. A method including

communicating requests and responses between a client and a server;

sending data between said client and said server using a memory access operation at an address agreed by said client and said server, wherein said address is responsive to information in said requests or said responses.

27. A method as in claim 26, including

receiving said data at one of said client or at said server in a first order; and

processing said data at said one device in a second order unrelated to said first order.

ABSTRACT

The invention provides a method and system in which a client/server system uses a NUMA communication link, possibly in combination with a byte serial communication link, to transfer relatively large blocks of data between client and server. The method and system provides for transferring data between the client and server, in which timing for the actual data transfer is decoupled from a request (from the client) or a response (from the server). The method and system also provides for transferring data from either party to the other at mutually agreed locations, such as locations responsive to control information present in either the request or the response. Accordingly, either party can transfer data to the other at a location convenient to both the sender and the recipient, and either party can process data in any order it prefers, without regard for the order in which data is stored at the other party.

Fig. 1

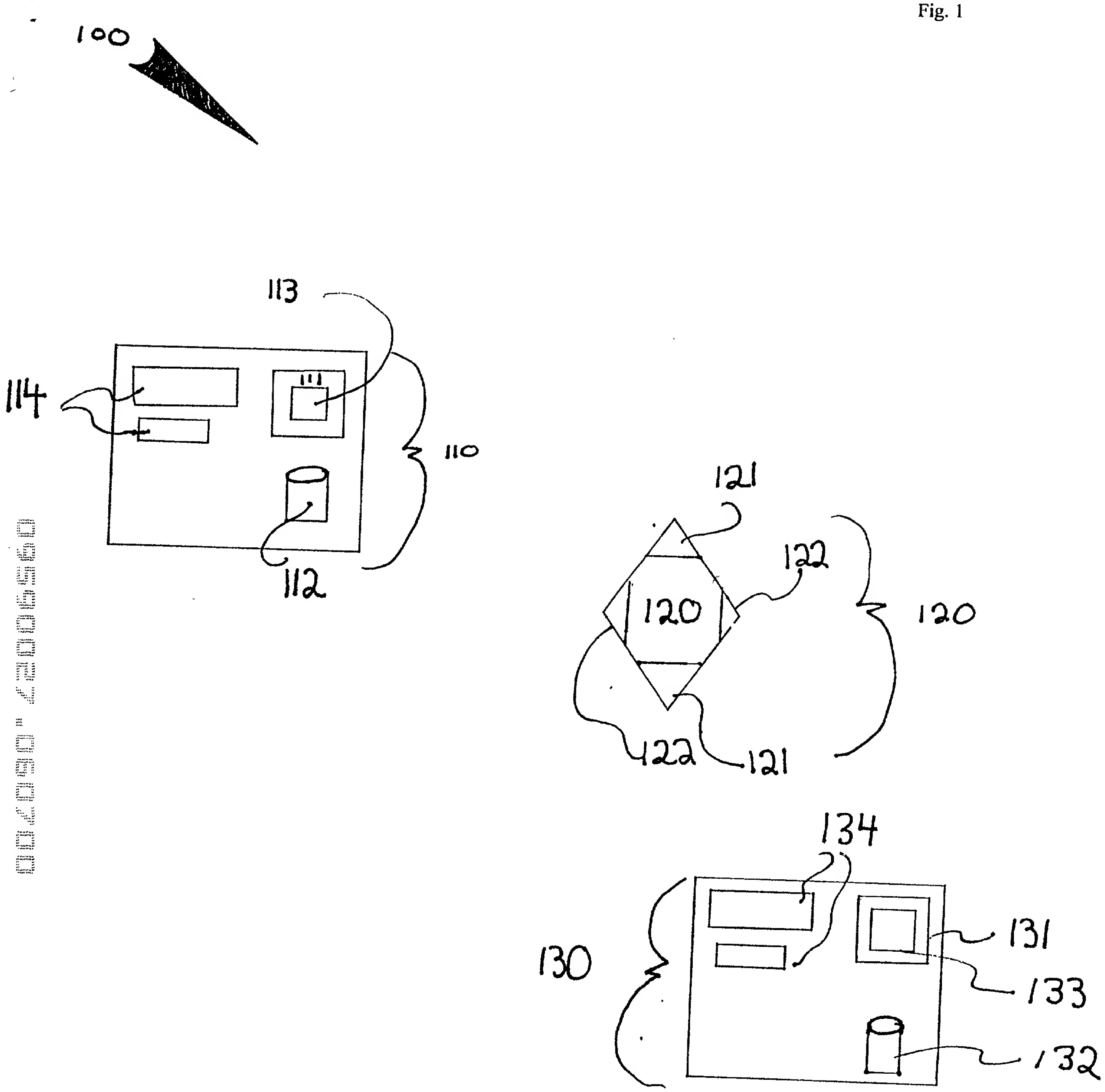
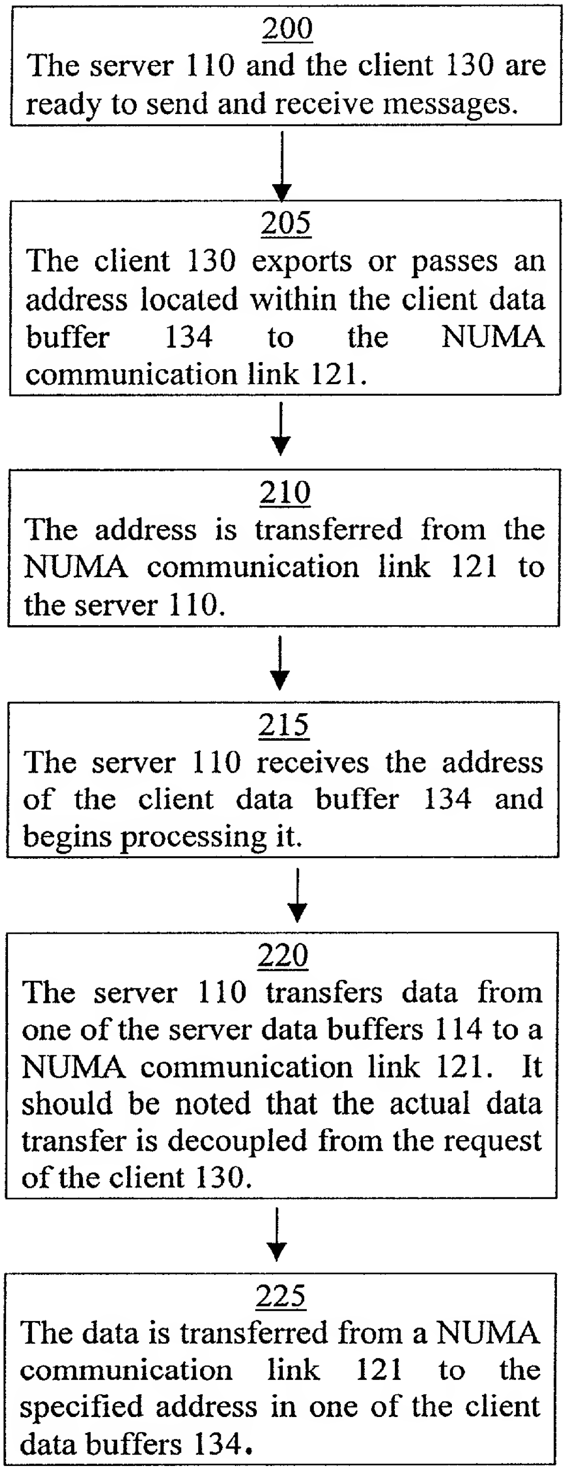

100
113
111
114
110
112
121
122
120
120
122
121
134
131
130
133
132

Fig. 2



200
The server 110 and the client 130 are ready to send and receive messages.

205
The client 130 exports or passes an address located within the client data buffer 134 to the NUMA communication link 121.

210
The address is transferred from the NUMA communication link 121 to the server 110.

215
The server 110 receives the address of the client data buffer 134 and begins processing it.

220
The server 110 transfers data from one of the server data buffers 114 to a NUMA communication link 121. It should be noted that the actual data transfer is decoupled from the request of the client 130.

225
The data is transferred from a NUMA communication link 121 to the specified address in one of the client data buffers 134.